Drivers of the Exceptional Warmth over Northern Asia during the Spring of 2020

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Source: https://news.mongabay.com/2020/07/photos-show-scale-of-massive-fires-tearing-through-siberian-forests/

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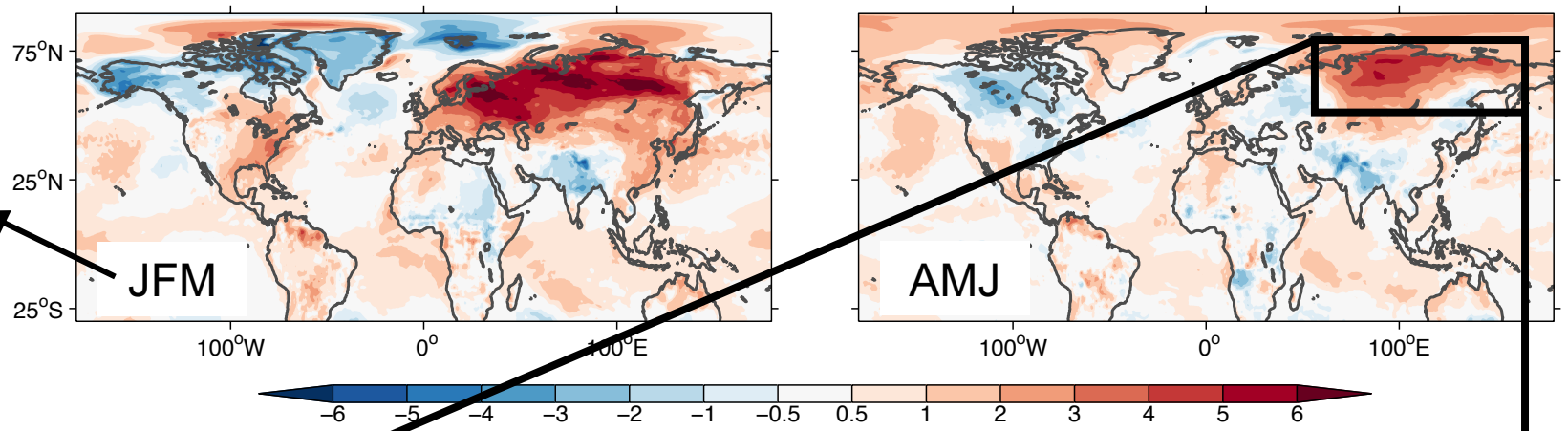
Spring 2020 put into context

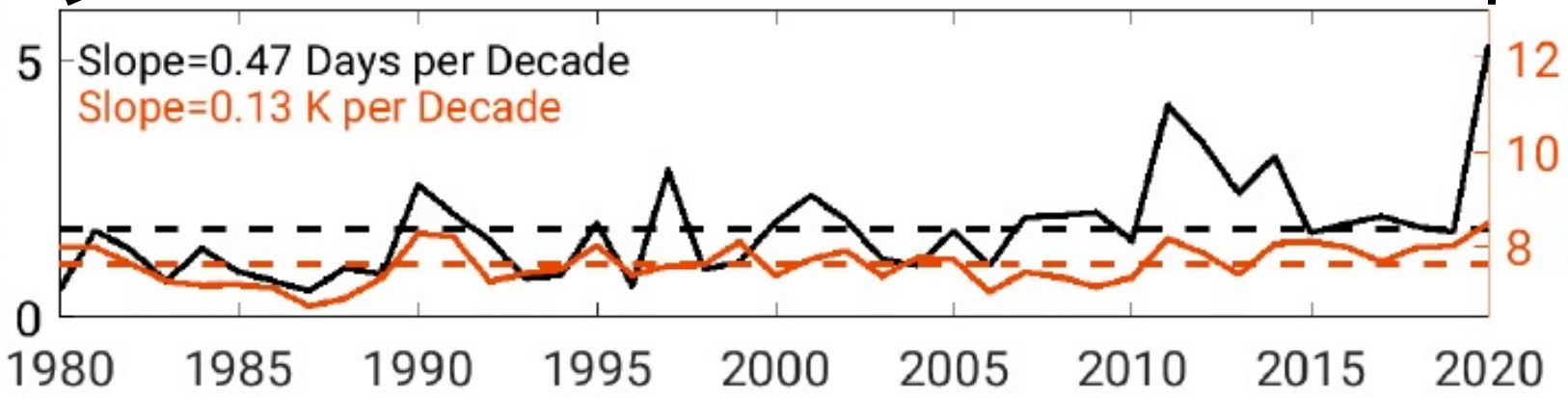
Schubert
14B.3
Thu, Jan. 27th
11:15 CST
J. Climate 2022
doi TBD

MERRA-2 seasonal mean 2m temperature anomalies in 2020 (K)



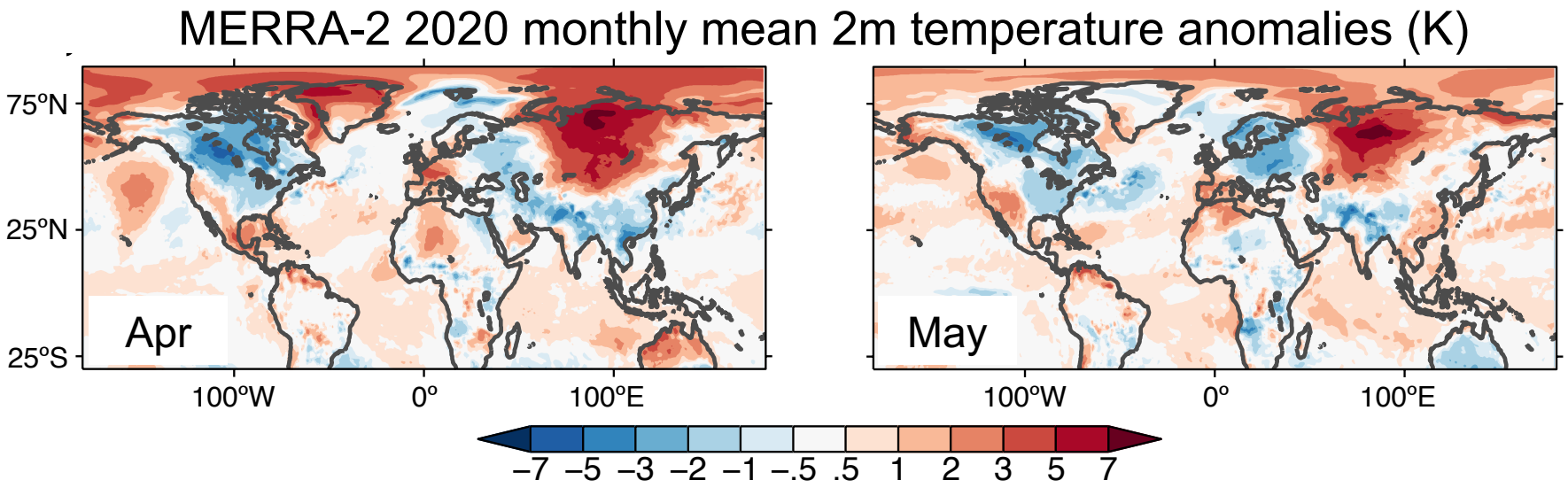
Warm spring was a continuation of the exceptionally warm winter

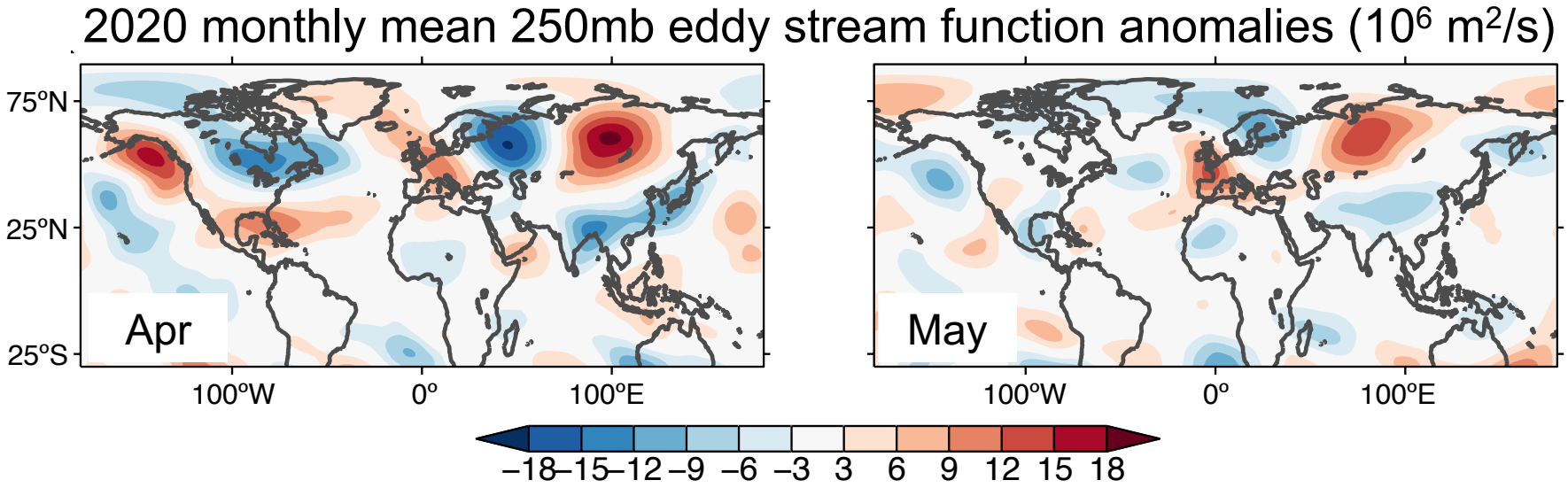
AMJ Seasonal and Regional Mean Heatwaves



Source: Collow et al. (2022), J. Climate, doi: 10.1175/JCLI-D-21-0432.1

Persistent anomalies in April and May

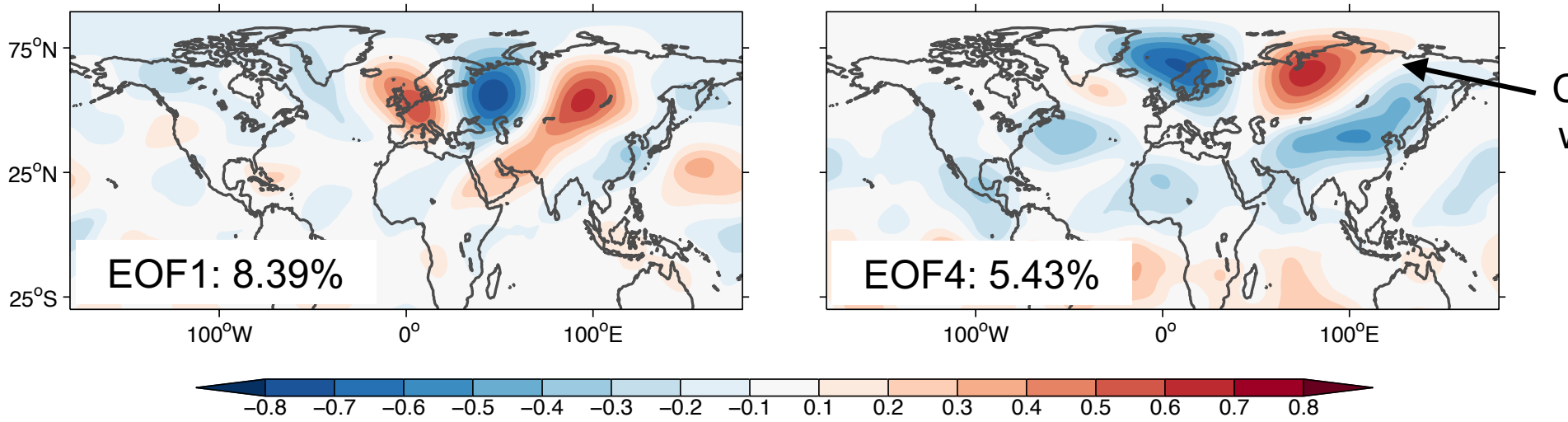




How unusual were the wave trains in 2020?

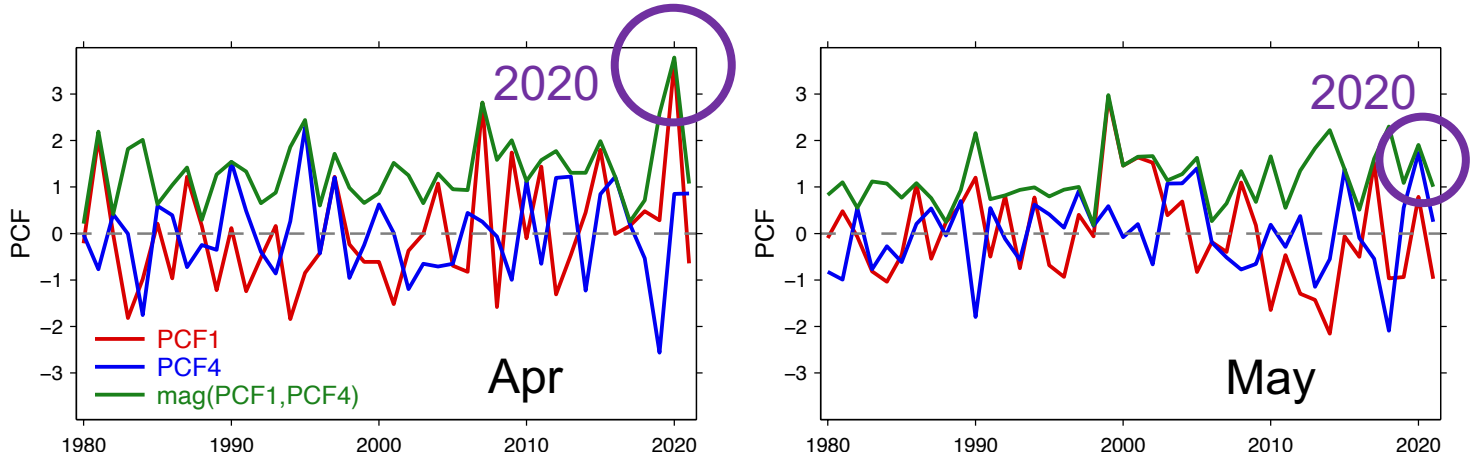
Wave trains quantified in MERRA-2

Apply rotated EOF analysis to Apr and May 250mb v-wind for 1980-2021:



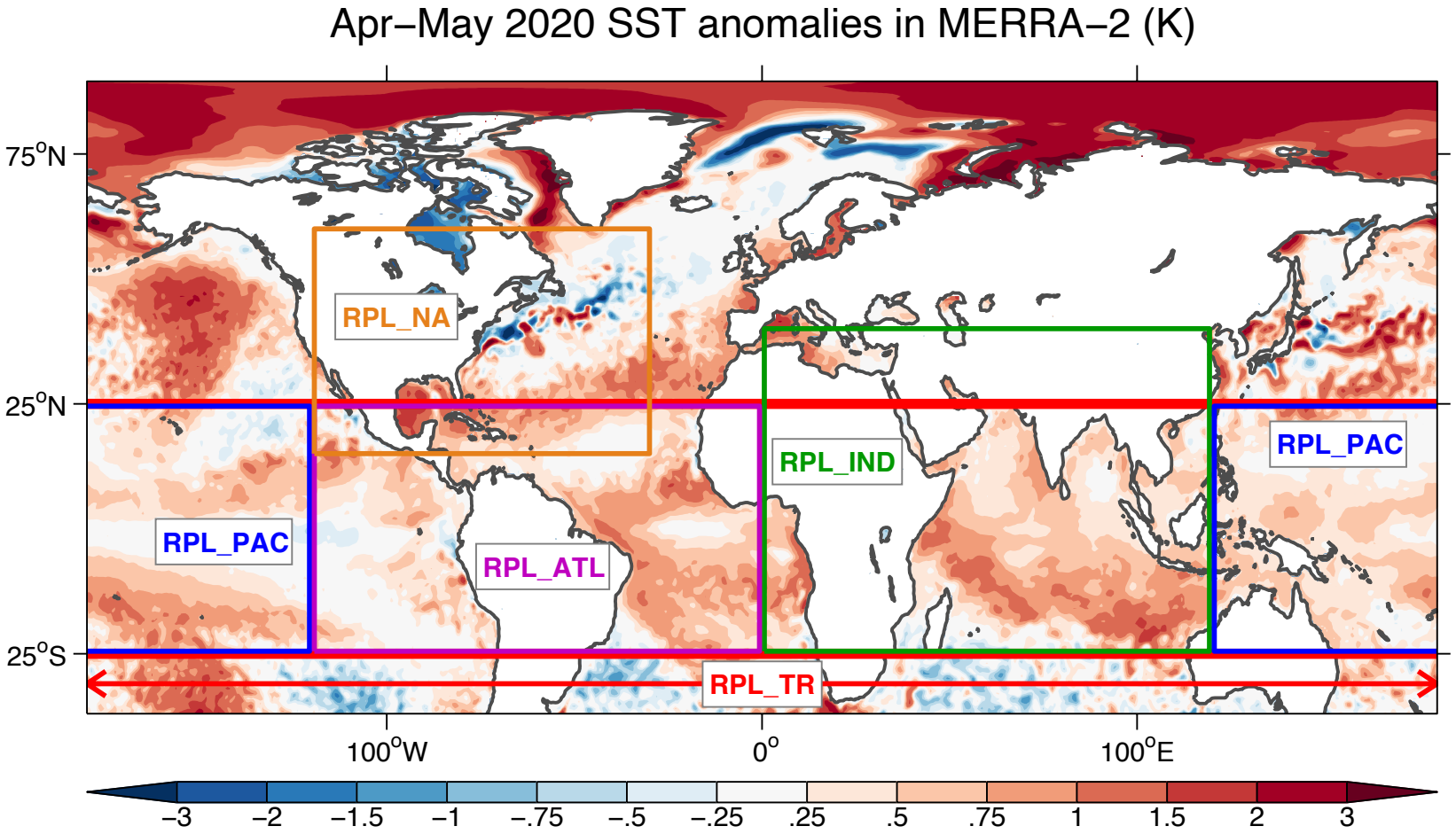
Corr. of PCs with 250mb stream function

April 2020 wave train was the most extreme manifestation of EOF1 in 42 years



What caused the wave train, and did any other factors contribute to the warmth?

Experimental design to explore remote drivers of wave trains



"Regional replay" experiments with NASA-GEOS atmospheric model
- *force atmosphere to remain close to observations in selected region*

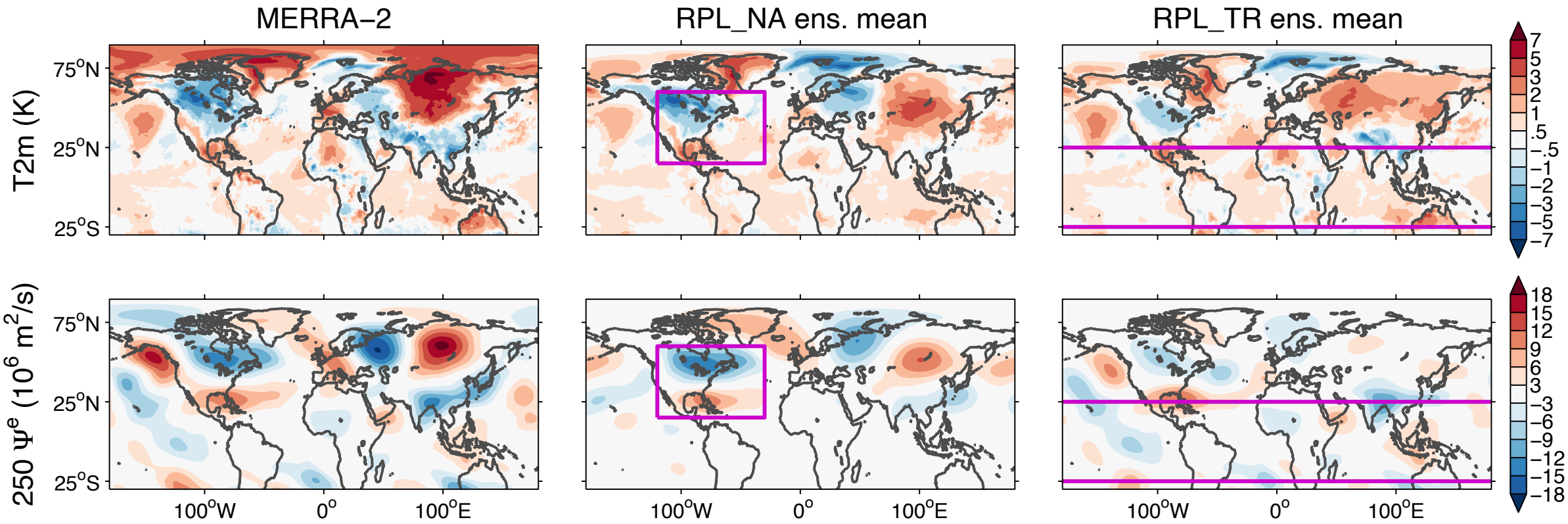
6 experiments: RPL_TR, RPL_PAC, RPL_ATL, RPL_IND, RPL_NA, and NORPL (all observed SSTs)

2020 runs: 90 ensemble members per experiment, init. 11/30/2018

climate runs: 1 ensemble member per experiment, init. 5/31 each prior year (1981-2019)

Model runs described further in Schubert et al. (2022), J. Climate, doi: TBD

April 2020 anomalies in MERRA-2 and AGCM runs

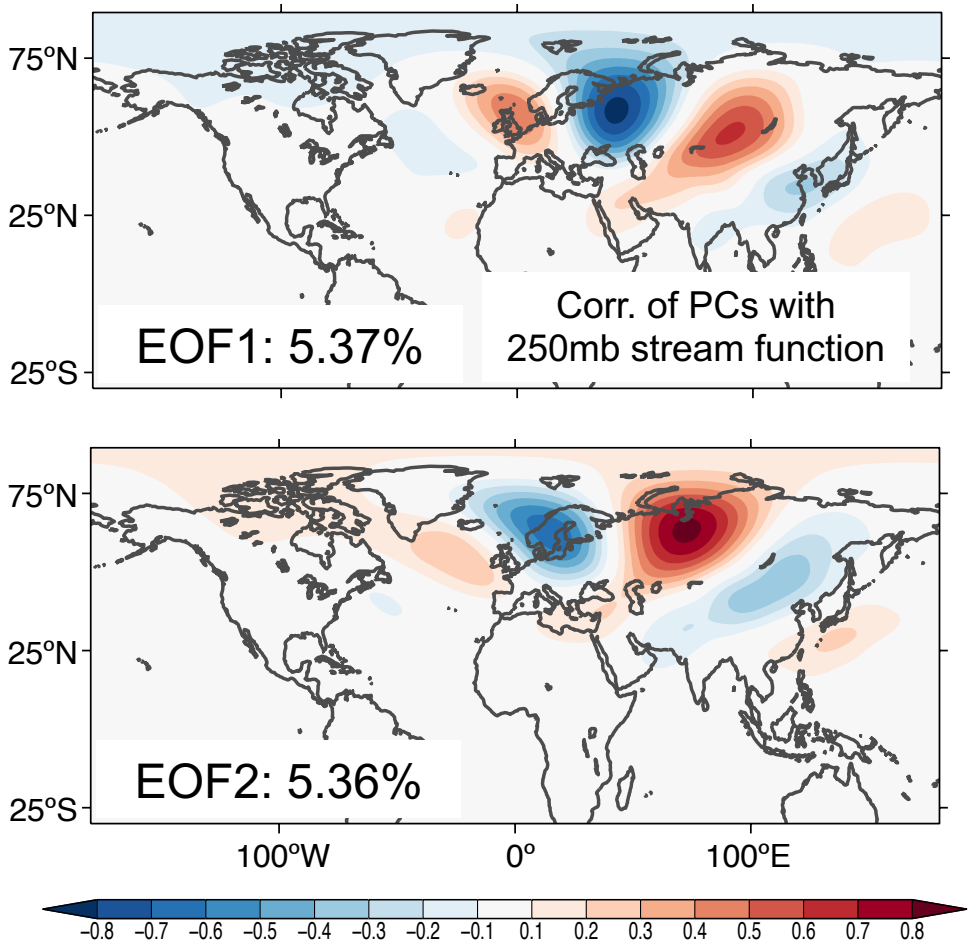


1. *April 2020 wave train was forced from the upstream extratropics*

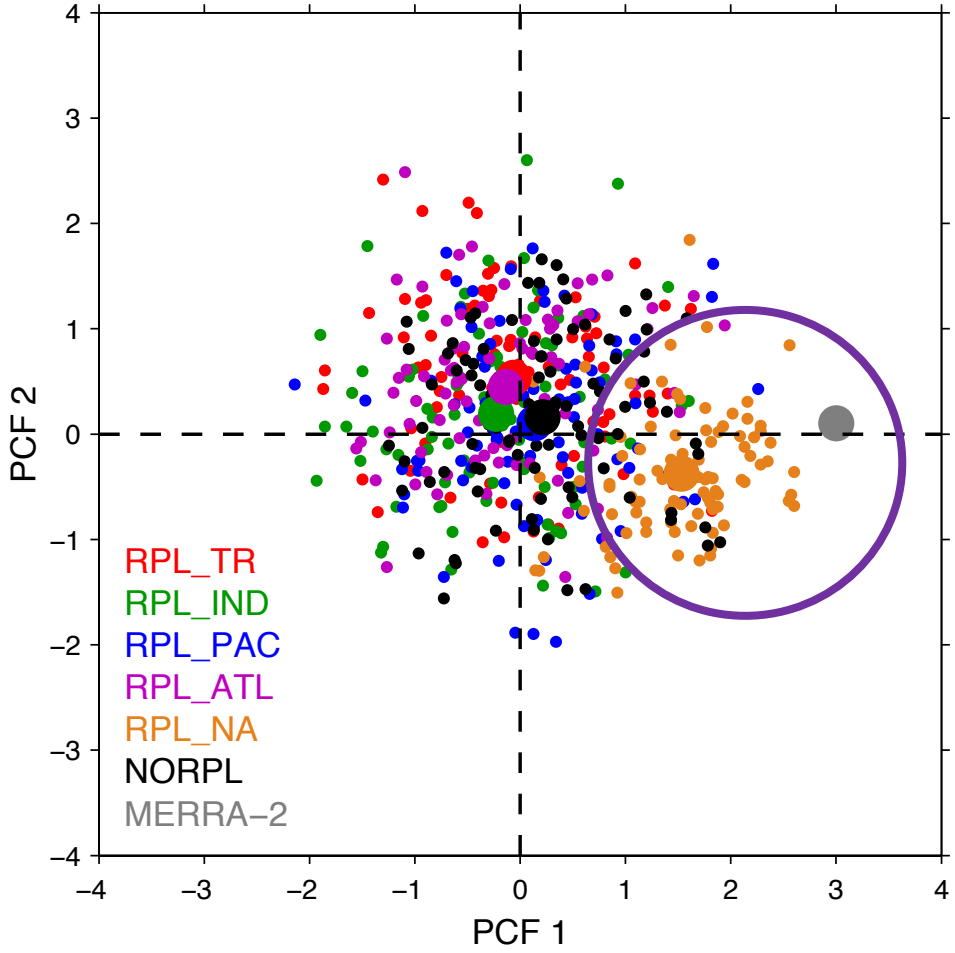
2. *Tropics forced some of the warming in April 2020, unrelated to a wave train*

Wave trains quantified in AGCM experiments

Rotated EOF analysis on Apr and May AGCM 250mb v-wind for 2020:



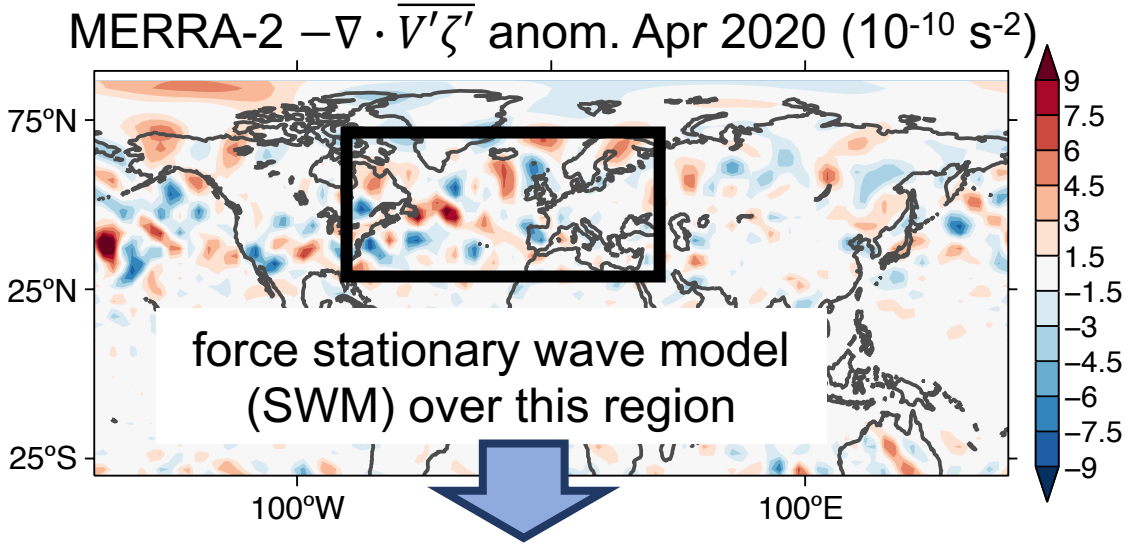
April 2020 250mb v-wind projected onto EOFs for each member:



RPL_NA members are much more likely to produce a strong wave train resembling EOF1

What is the nature of the upstream forcing that causes the wave train?

Subdaily internal dynamics key for producing wave train

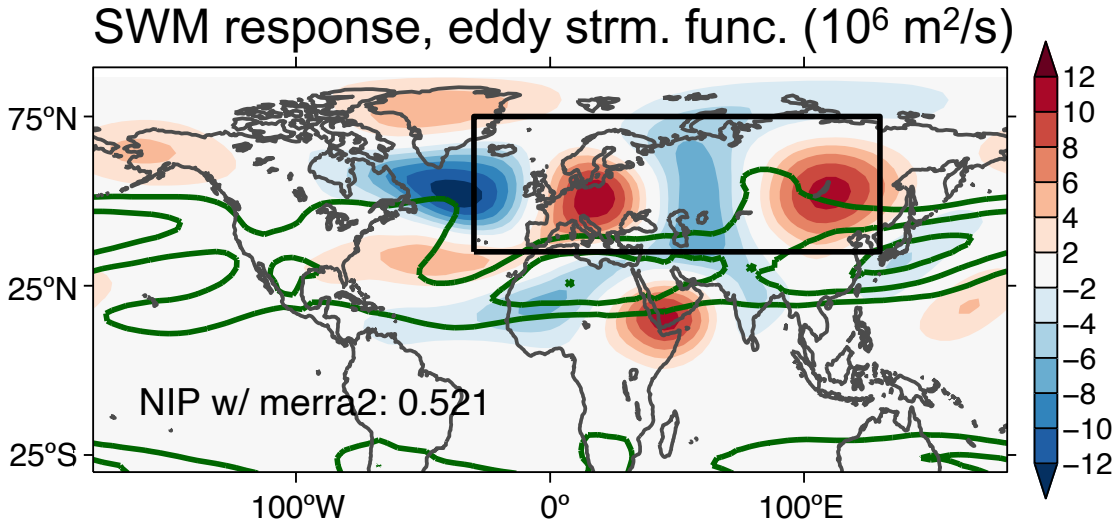


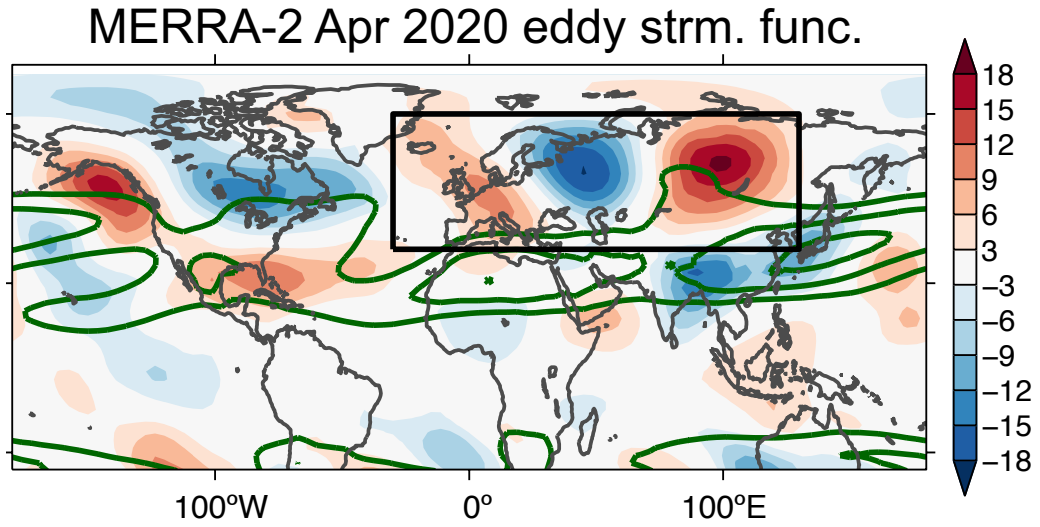
Transient vorticity flux convergence:

$$-\nabla \cdot \overline{V'\zeta'}$$

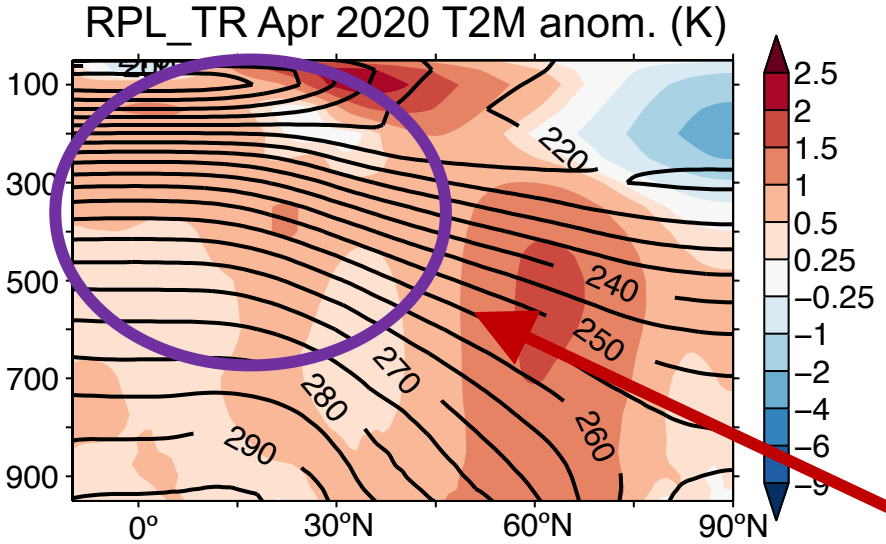
forces changes in vorticity, $\frac{\partial \zeta}{\partial t}$

computed from 6-hr deviations from the monthly mean

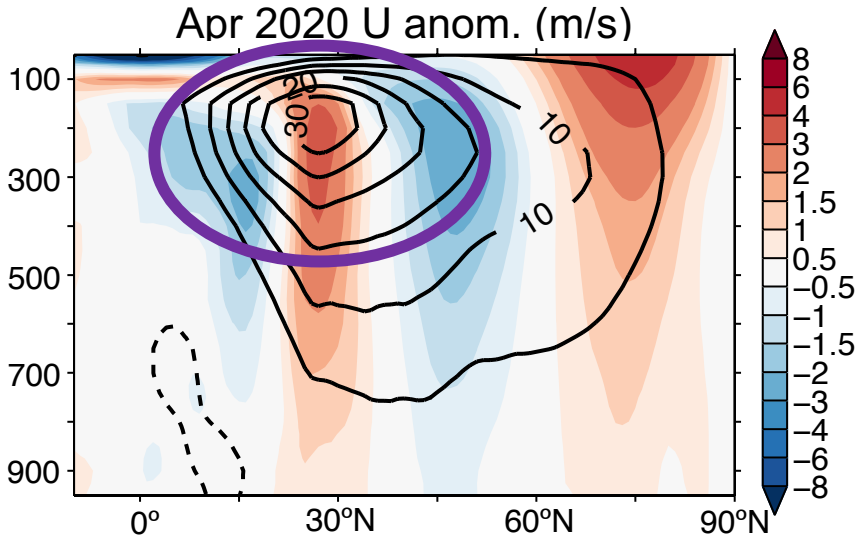




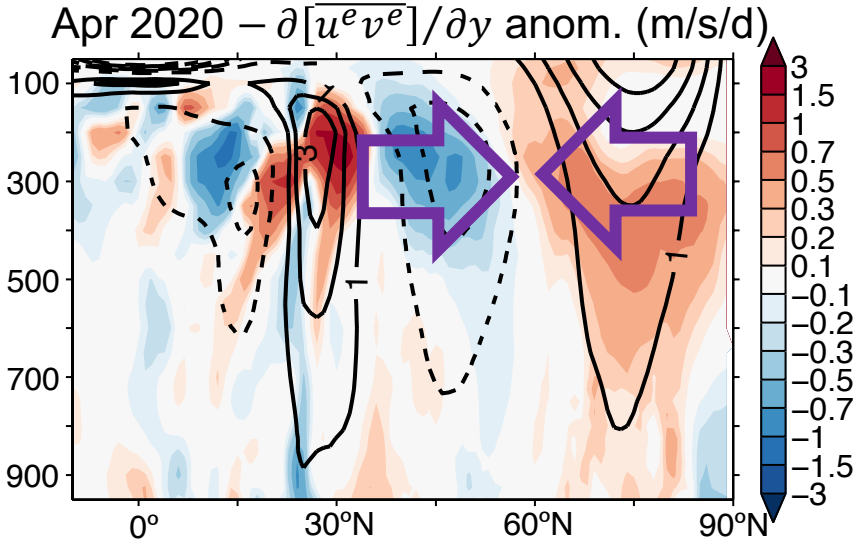
How did the tropics cause warming in northern Asia?



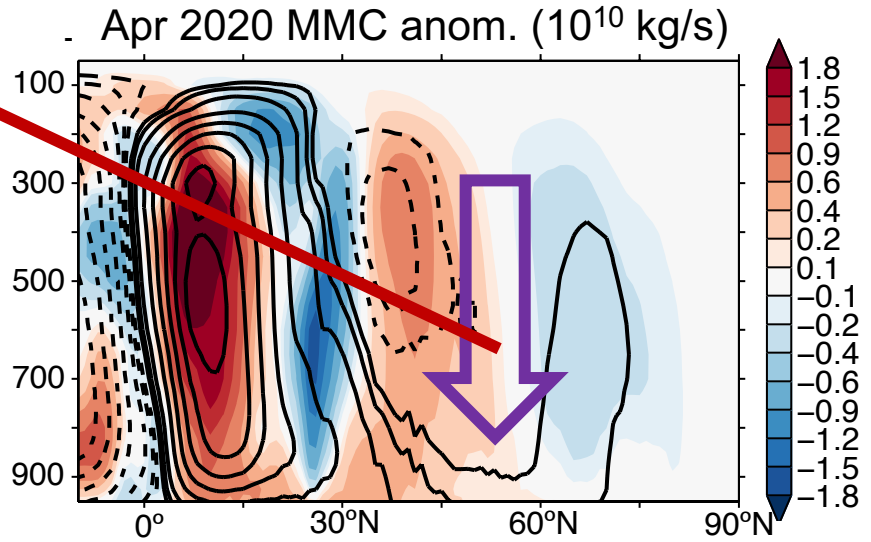
1. *Warm SSTs warmed tropical atmosphere (latent heat) and strengthened upper atm. T gradient*



2. *Strengthened subtropical jet stream and altered atmospheric basic state*



3. *Anomalies in eddy momentum flux convergence → forces anomalies in meridional wind*



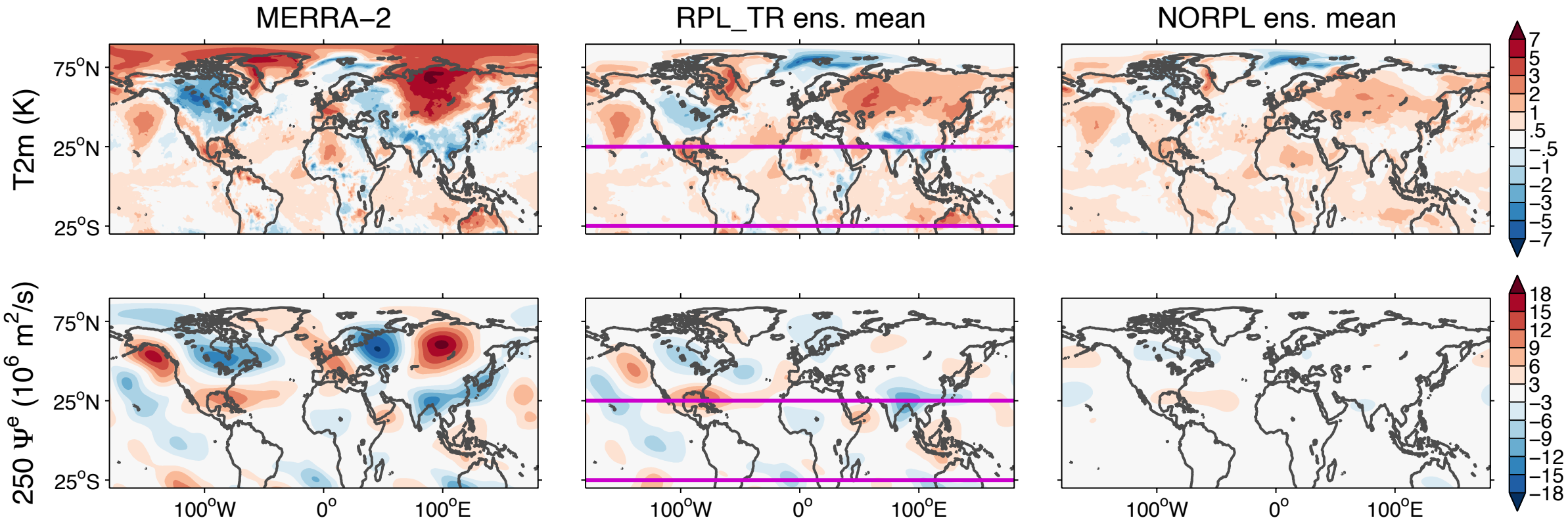
4. *Weakened Ferrel and Polar cells, causing anomalous descent and adiabatic warming*

Summary and Conclusions

- Extreme warmth in northern Asia during April-May of 2020 was driven by two key dynamical mechanisms.
  1. Eurasian Rossby wave trains that were forced by internal high-frequency atmospheric dynamics over North America and the North Atlantic.
  2. A teleconnection from the tropics whereby the warm tropical SSTs altered the upper atmosphere wave dynamics and ultimately the mean meridional circulation.
- The nature of the forcing for the wave trains (caused by presumably chaotic internal subdaily processes) suggests limited predictability of the wave train (and thus extreme warmth) beyond the weather prediction (1-2 week) time frame.
- To the extent that the warm tropical SSTs in 2020 were attributed to long-term anthropogenic climate change, one may conclude that the extratropical extreme warmth due to the wave trains was made more intense due to climate change.

Extra slides

April 2020 anomalies



April 2020 anomalies